REPORT ON RETROFIT
FIREPLACE DAMPER

September 1983

Prepared By:

DR. M. HATZINIKOLAS, P. ENG.

The views and conclusions expressed and the recommendations made in this report are entirely those of the authors and should not be construed as expressing the opinions of the Alberta Department of Housing.

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FOREWORD

This study was made possible with funding provided by the Innovative Housing Grants Program of the Alberta Department of Housing. Originally conceived in 1978, the Program is intended to encourage, sponsor, and assist research and development in the fields of housing, site and subdivision design, energy conservation, site servicing and urban development. Generally, the aims of research funded by the Innovative Housing Grants Program are to reduce housing costs, increase the supply of appropriate housing or improve the utility or performance of dwelling units or subdivisions.

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Innovative ideas come from a wide variety of applicants such as builders, developers, consulting firms, industry associations, municipal governments, educational institutions, non-profit groups and individuals. As the type of project and level of resources vary from applicant to applicant, the resulting documents are also varied.

Where possible the Department encourages the dissemination of study results under a standard cover and in a uniform format. This study, Report on Retrofit Fireplace Damper, was completed in April 1980 and subsequently released under a different cover.

Please send comments and suggestions or requests for further information to:

Innovative Housing Grants Program
Fourth Floor
10050 - 112 Street
Edmonton, Alberta
T5K 2J1

Alberta Department of Housing
September 1983

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Alberta
DEPARTMENT OF HOUSING

Innovative Housing Grants Program

RETROFIT FIREPLACE DAMPER

M. Hatzinikolas, P. Eng., H. Morstead

The retrofit fireplace damper (trade name MI - CAP C1980 Fireplace Damper) is a new invention that has the potential to improve the efficiency of fireplaces and other heating devices utilizing chimneys. The MI - CAP when installed will:

1) eliminate cold air draft;

2) eliminate snow and rain penetration; and

3) limit heat loss.

Air Movement

Most site built masonry fireplaces have poorly fitting dampers and this is often cited as a source of uncontrolled air leakage.

There are three possible conditions of air movement through a chimney:

1) flow of heated air from inside the building to the outside resulting in energy loss;

2) flow of cold air down the chimney and into the enclosed living area;

3) no movement (neutral equilibrium), which often causes cooling of the chimney and surrounding materials (bricks, blocks, etc.) which in turn generates convection currents in the room containing the fireplace.

Mi-Cap Design and Operation

The device illustrated consists of a removable cap, corner supports, angle frame steel flap, non-combustible cable, cross bar and accessories. The whole assembly is designed to be force fit into a standard clay flue liner from the top of the chimney. The user can operate the device with cables from the fireplace. The damper is closed by pulling on the "close" cable and will remain closed by attaching a small weight to the cable. The damper will open by removing the weight.

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RETROFIT FIREPLACE DAMPER

M. Hatzinikolas, P. Eng., H. Morstead

(Cont'd)

If the plate becomes frozen shut or jammed, it can be forced open by pulling on the "open" cable.

Testing Mi-Cap

MI-CAP has been tested by the Alberta Research Council and in a number of homes in Edmonton during the coldest part of the winter season. The researchers of the Council noted, "If air infiltration is occurring through an existing chimney this device should virtually eliminate this air flow". The residents of the test homes also reported elimination of drafts and increased comfort.

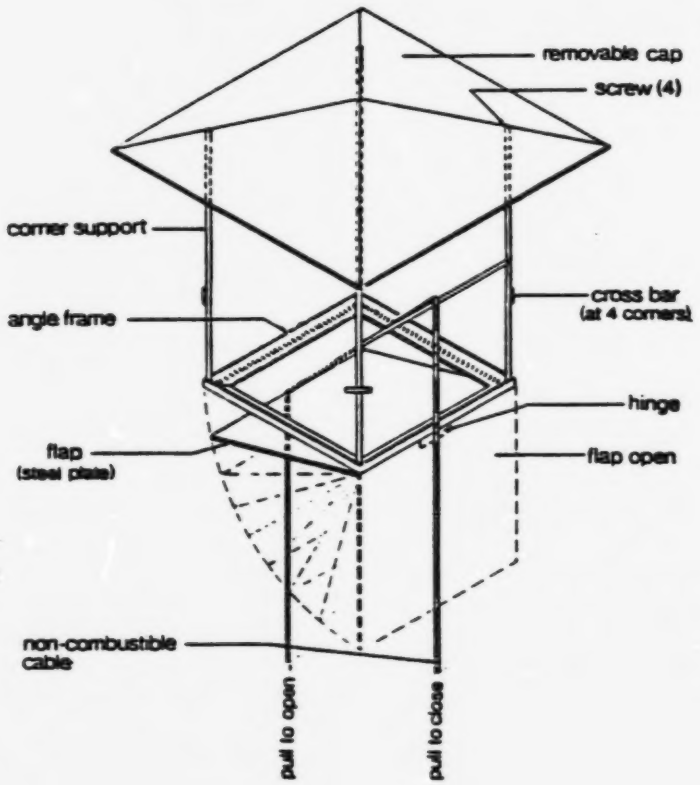


Fig. 1. Retrofit Fireplace Damper

PHASE 1

Results of experimental evaluation of the device are given in a report prepared by the Alberta Research Council. The experimental evaluation of the device both in the laboratory and in the field was carried out by Mr. William Bear, P.Eng.

The materials used in manufacturing the device met the approval of the above mentioned researcher. His report is attached, and covers the tasks of paragraphs a to d of Phase 1.

AIR LEAKAGE THROUGH RETROFIT FIREPLACE DAMPER

INTRODUCTION

Mr. Mike Hatzinikolas, P. E.g., and Mr. Harry Morstead requested the assistance of Industrial and Engineering Services Division of the Research Council of Alberta to evaluate a fireplace damper they have developed. Most site built masonry fireplaces have poorly fitting dampers and this is often cited as a source of cold drafts. One solution would be the retrofitting of the flue liner with a tight sealing damper and this is the approach taken by Messrs. Hatzinikolas and Morstead. Evaluation of such a device is difficult and most testing must take place on site in an actual fireplace. One valid laboratory test is to measure air leakage past the damper as a function of static pressure and this is the object of this report.

DESCRIPTION OF THE DAMPER

The damper, as tested, is designed to fit inside a standard 12 inch clay flue liner (approximately 10" x 10" inside measurements). Two 1/8" steel plates approximately 10 inches square with a 9" square hole are bolted together with a 1 inch wide woven asbestos tape clamped between them to act as a seal against the flue liner. A hinged damper plate of 14 gauge steel closes against the steel ring and is actuated by a wire running up the flue and hence will fall open should the wire break. A raincap of galvanized steel completes the unit. The whole assembly is force fit into the flue liner from the top of the chimney and the damper is typically located 9 to 12 inches below the top of the existing chimney.

TEST PROCEDURE

Figure 1 illustrates the test apparatus utilized. Air is forced into 4.00 inch internal diameter ABS pipe by a 1/2 h.p. blower. The volume of air is measured by the pressure drop across a circular orifice located in the centre of the pipe run. A plywood duct 12 inches square on the inside with a section of clay liner acted as a chimney. All joints were caulked and a diffuser was placed in the plywood duct to distribute the airflow. Static pressure against the damper was measured as well

as the absolute pressure downstream from the orifice for air density correction. All pressures were measured using Dwyer inclined monometers. Movement of the fan and use of a damper in the Y fitting allowed a variation in the flow rate.

RESULTS

The flow through the orifice, i.e. the damper leakage, was calculated from the following equation.

$$Q_m = CA_2 \sqrt{\frac{2g \times 2.4 \times W_m h_o}{\left[1 - \left(\frac{d_2}{d_1}\right)^4\right] \times 12}} \quad \frac{60}{W_m}$$

where Q_m = flow, cubic feet/minute

A_2 = orifice area, feet^2

C = discharge coefficient

W_m = density of air at meter (lb/ft^3)

d_1 = inside diameter of pipe, inches

d_2 = orifice diameter, inches

Note: the correction to W_m was so small that 0.07 lb/ft^3 was taken as the air density for all calculations.

Tabulated test data and computed flow rates are shown in Figure 2 and the air leakage pc. the damper versus static pressure, both negative and positive, is plotted in Figure 3.

DISCUSSION

The results plotted on the log-log scale of Figure 3 follow the expected relationship

$$Q = C\Delta p^n$$

where Q = flow rate

C = proportionality constant

Δp = pressure difference

n = exponent of flow

Normally the exponent of flow, n, is between 0.5 and 1.0; here it is 0.59 for Δp positive and 0.68 for Δp negative and the respective proportionality constants are 10.9 and 16.3. One would expect different leakage rates for positive and negative pressure differences from the design of the damper. Positive pressure (below the damper) would be expected to form a tighter seal than a negative pressure which would tend to open the damper (a consequence of the fail-safe design) and this is indeed the case experimentally.

Static pressures or pressure differences between the inside and outside of buildings arise from several interrelated factors, the principle of these being temperature differences, wind velocity, construction techniques, furnace or fireplace operation and exhaust fans. The interplay between these factors is complex and the actual pressure difference depends on the location and heigh within the building. Normally these differences are small in the order of a few hundredths to a few tenths of an inch water gauge. Sometimes values can approach 1 inch water gauge but this is very infrequent. Figure 3 covers the general range of pressure differences obtained in most residences.

The damper tested is quite tight and compares well with a conventional double hung window for which ASHRAE gives figures of 27 to 90 cubic feet per hour per foot of crack at 0.10 inches water gauge. This compares to 45 CFH for the damper under the same conditions. While the author has no comparable data on conventional fireplace dampers, leakage would be expected to be very much higher probably an order of magnitude or more at any pressure differential.

SUMMARY AND CONCLUSION

An air leakage test has been performed on a new fireplace damper designed to be retrofitted into existing masonry chimneys. Air leakage against static pressure is given in Figure 3 and these results follow expected relationships. The damper seal is quite good, indeed excellent, when compared to conventional dampers in site built masonry fireplaces. If air infiltration or exfiltration is occurring through an existing chimney this device should virtually eliminate this air flow. This statement is not intended to include thermal drafts caused by differences in temperatures between the masonry and the normal room temperature.

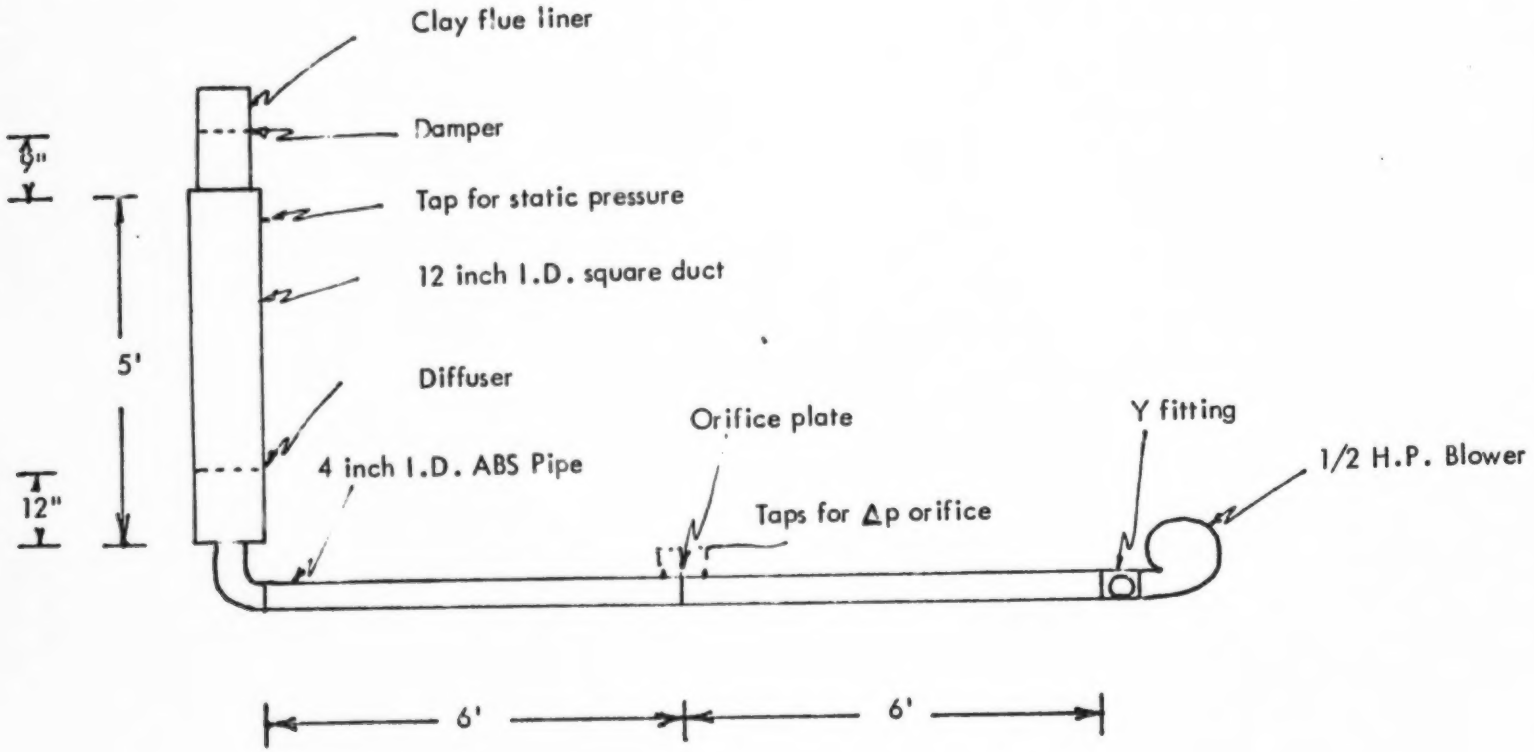


FIGURE 1. Test apparatus for measuring damper leakage.

FIGURE 2. TEST RESULTS

Test Conditions	Test	Δp across orifice, Inches H_2O	Pressure downstream of orifice Inches H_2O	Static pressure at damper Inches H_2O	Flow cfm
	Negative Pressure (Suction) (down draft)	4.55	4.70	0.275	7.0
		3.60	3.50	0.240	6.2
Barometric pressure 27.20 in Hg		2.75	2.70	0.200	5.45
		1.850	2.10	0.155	4.4
Wet bulb Temp. 57°F		1.530	1.75	0.135	4.07
Dry bulb Temp. 70°F		1.210	1.40	0.110	3.6
Relative Humidity 46%		0.870	0.965	0.090	3.07
		0.780	0.870	0.080	2.9
0.492 inch orifice		0.540	0.625	0.060	2.42
		0.380	0.460	0.045	2.0
		0.315	0.360	0.040	1.65
		0.180	0.215	0.030	1.3
		0.125	0.155	0.020	1.1
		0.050	0.065	0.010	0.74
	Positive Pressure (updraft)	4.35	0.410	0.470	6.86
		3.85	0.395	0.440	6.4
		3.40	0.340	0.380	6.06
		1.970	0.185	0.230	4.6
		1.645	0.165	0.195	4.21
		2.90	0.230	0.270	5.6
		1.550	0.160	0.190	4.0
		1.415	0.145	0.175	3.9
		1.225	0.135	0.150	3.6
		1.060	0.115	0.135	3.38
		0.695	0.085	0.095	2.7
		0.360	0.045	0.055	1.97
		0.075	0.020	0.15	0.1 5

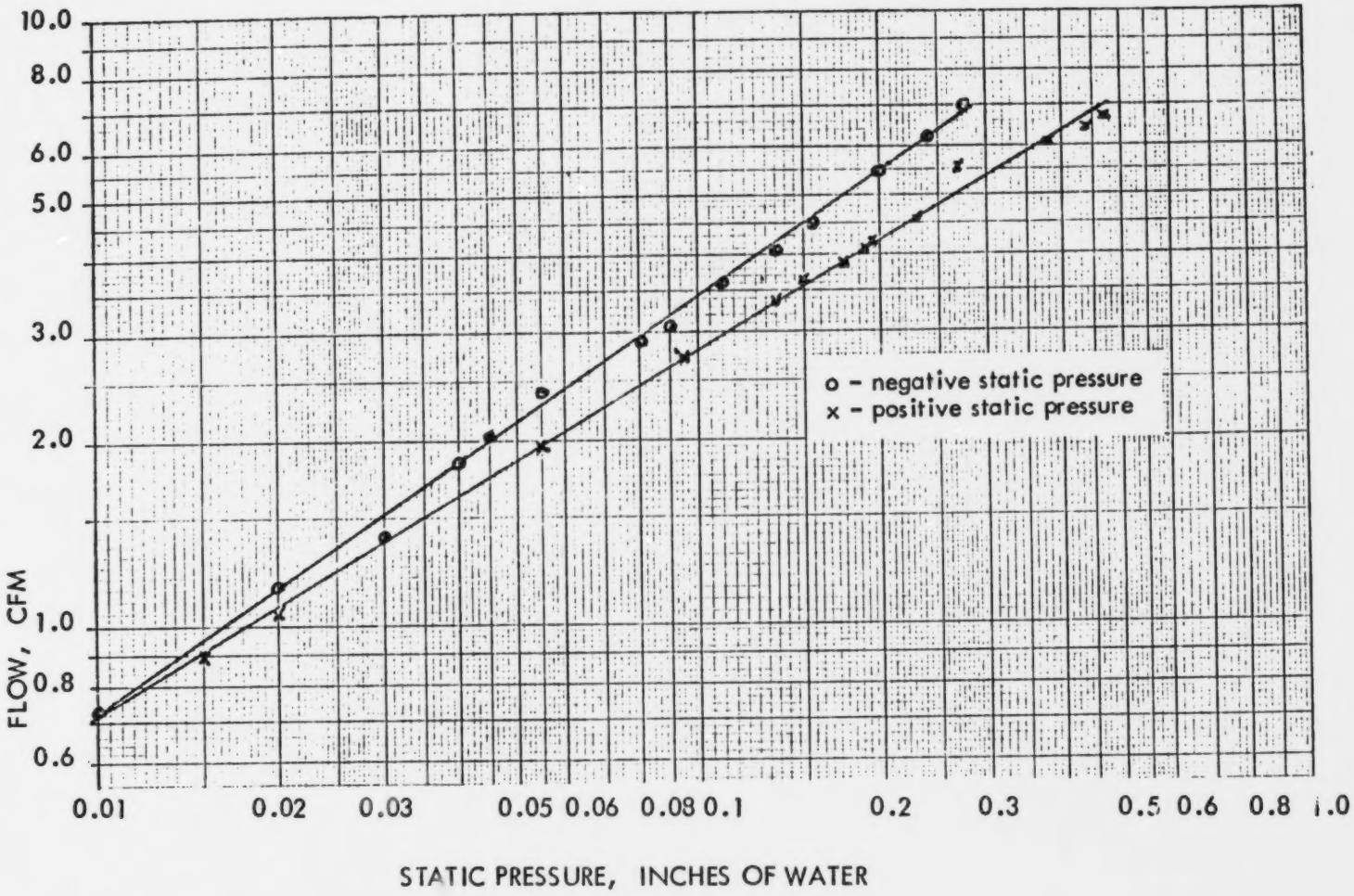


FIGURE 3. Air flow through the damper as a function of static pressure.

PHASE 2 AND 3

The device was modified a number of times during the process in order to decrease the manufacturing cost, by reducing the materials needed and to increase speed of manufacturing.

The device as tested in the field is shown in Photograph 1. Drawings of the device are attached at the end of this short report.

The first field installation was carried out at the residence of Mr. Lyle and Joyce Johnson located at 1031 - 75 Street. Installation time was approximately 10 minutes. The work was carried out in January under very cold weather conditions. The chimney was found to be wet prior to installing the device, and snow fell into the house when we opened the lower damper.

The owners of the house were complaining about cold drafts and they were unable to use the area around the fireplace without having a fire going (it was very cold). After installing the device we received a letter from Mr. and Mrs. Johnson which states that the damper has been very effective. Further to the evaluation of the device by the users, Mr. W. Bear of ARC was asked to examine its performance under field conditions.

Photo 1 Damper similar to the ones installed in Edmonton area.

Mr. Bear has concluded after visiting the home of Mr. and Mrs. Johnson that no further testing is required and that if air infiltration or exfiltration is occurring through an existing chimney this device should virtually eliminate this air flow. Another device has been installed at the residence of Mr. Bill Irwin located at 4144 - 110 Street. Mr. Irwin is also very pleased with the performance of the device.

January 8, 1979

Dr. Michael Hatzi..ikolas
Director of Technical Services
Alberta Masonry Institute
Suite 200, 10712 - 176 Street
Edmonton
T5S 1G7

Dear Mike:

Thank you for installing the new damper system on our fireplace. Previously, we had quite a bit of trouble with drafts coming down the chimney and making the fireplace area a cold area. However, with the instalation of this system these cold drafts have been completely eliminated.

Sincerely,

J. Johnson per

Lyle and Joyce Johnson
1031 - 75 Street
Edmonton, Alberta
T6K 2R7

Alberta RESEARCH COUNCIL

Industrial and Engineering Services

403/432-8181
Telex 037-2147
11315 - 87th Avenue
Edmonton, Alberta, Canada
T6G 2C2

March 25, 1980

Mr. Michael Hatzinikolas
Director of Technical Services
Alberta Masonry Institute
Suite 200
10712 - 176 Street
Edmonton, Alberta T5S 1G7

Dear Mr. Hatzinikolas:

Further to our report entitled, "Air Leakage Through Retrofit Fireplace Damper" of June 11, 1979, the Research Council of Alberta agreed to attempt in-service measurements on existing fireplaces this winter. Unfortunately the measurement of air infiltration is a difficult procedure especially when the rates are low. Also the rate of infiltration depends on external factors such as temperature and wind speed and direction which do not usually coincide with the experiment. Hence we were unable to quantify any reduction in air infiltration after installation of the damper although subjectively a difference was noted. To accurately measure air infiltration would mean sealing an entire house and measuring infiltration against a known pressure differential created with fans. This would entail considerable costs and the results would only be applicable to the particular house.

In our opinion the previous report adequately demonstrates the air tightness characteristics of the damper and further testing is not warranted. We repeat our conclusion that if air infiltration or exfiltration is occurring through an existing chimney this device should virtually eliminate this air flow. This statement is not intended to include thermal drafts caused by the temperature differential between the masonry and the rest of the house.

Yours very truly,

W. H. Bear, P. Eng.
Industrial and Engineering Services

WHB:bw

PHASE 4

This invention relates to a new and useful improvement for fireplaces and other heating devices utilizing chimneys. Fireplaces are usually equipped with a damper located just above the fire box. This damper is often damaged at the time of installation, or is affected by heat and differential movements in such a way as to allow large amounts of air movement.

There are three possible conditions for air movement through a chimney:

1. flow of air from inside the building to the outside, resulting in energy loss.
2. flow of air down the chimney and into the enclosed area, in which case the surrounding area is cooled and uncomfortable.
3. no movement at all (neutral equilibrium). For this and case (2) the total chimney and surrounding materials (bricks, blocks, etc.) are cooled substantially. Thus by contactivity they create a draft of cool air inside the room. (Warm air comes in contact with the cool surface of the face of the chimney (fireplace) and adjacent area, cools off and circulates).

These conditions are variable for the same unit, depending on weather conditions such as temperature, wind, pressure, etc., and the pressurization of the building (furnace on or off, air supply for combustion, etc.). Therefore most fireplaces have a stack of cold air which comes down to the damper (for the case of neutral equilibrium) and when one attempts to light the fire will prevent proper establishment of upward air flow. The result is that smoke enters the room and in many cases preheating of the chimney by burning newspapers, etc. is needed.

Water and snow penetration into the chimney can cause damage to the joints of the flue liner by freezing and thawing and thus can result in deterioration of the unit.

A device which can eliminate all of the above mentioned problems is very beneficial to the owners of properties with fireplaces. The invention described herein provides a solution for all those problems and as it will be explained in the following sections, is easily installed in new and existing fireplaces, does not freeze shut, does not interefere with the flow of air, does not cause turbulence, provides shelter from rain and snow and is fail safe.

The device is useful in conserving energy and providing for better fireplace operation and extension of

its life. The above and other objectives and advantages in connection with this invention are illustrated in detail as follows.

The device is shown in an isometric view and in a section on the attached drawing.

The device consists of a removable cap, corner supports, angle frame steel flap, non-combustible cable, a cross bar and accessories. It is lowered into a position as shown in the section and thus is not susceptible to freezing. It is closed by pulling on the cable indicated "pull to close" and it can remain closed by the small weight left hanging at the end of the cable inside the fire box.

The device will stay open if cables fail and it can be forced open by pulling on the cable "pull to open". When the weight is removed from the cable "pull to close", the device opens by gravity force (weight of steel flap).

The device can be used with or without the cover, a screen can be provided to prevent birds or foreign materials (leaves) from interfering with the operation.

There is considerable interest in the device by masonry supply companies. We hope that it will be on the market by the end of this summer. Mass production cost is estimated to be between 20 and 22 dollars. The device will cost around 60 dollars including installation costs.

SUMMARY AND CONCLUSIONS

1. Retrofiting chimneys with top mounted damper will eliminate or improve

   a) air infiltration

   b) air exfiltration

   c) snow and rain penetration

   d) air flow

   The above will positively affect:

   a) life expectancy of fireplace

   b) heat loss

   c) comfort

2. The damper can be installed by owners and it can be easily replaced.
3. Fail safe by virtue of its design.
4. It cannot freeze shut.

Alberta RESEARCH COUNCIL
Industrial and Engineering Services
403/432-8057
Telex 037-2147
11315 - 87th Avenue
Edmonton, Alberta, Canada
T6G 2C2

June 12, 1979

Dr. Michael Hatzinikolas
16743 - 113 Avenue
Edmonton, Alberta
T5M 2X2

Dear Mike:

Please find enclosed two copies of my report on the air leakage characteristics of your fireplace damper. The results are quite good and I do not feel much improvement could be achieved at a reasonable cost.

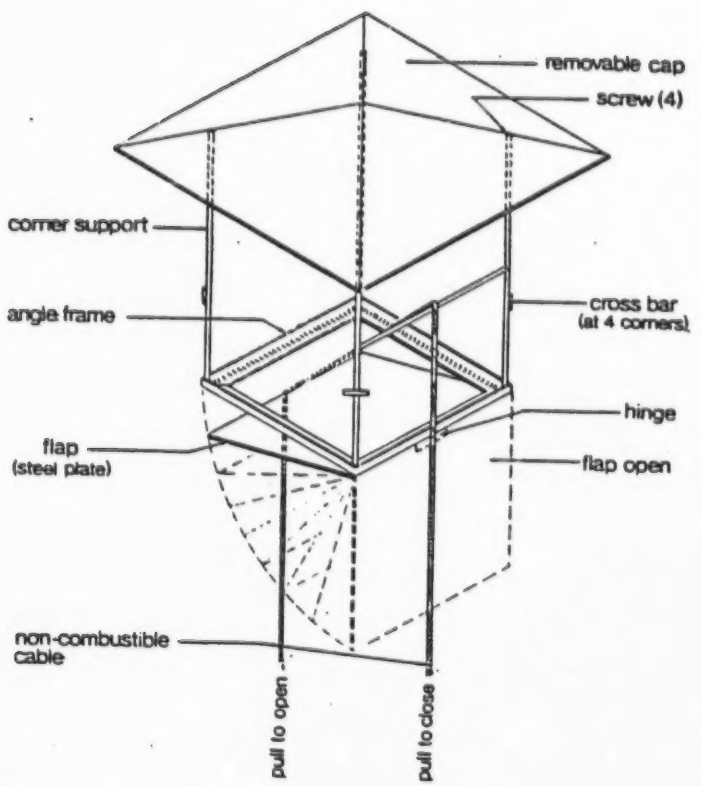
As I stated before, we will be pleased to assist you in the evaluation of your damper on an actual fireplace or fireplaces; however, these tests are best run in the winter time and we suggest that the in-service tests wait until cold weather arrives.

Best wishes,

Bill

W. H. Bear, P. Eng.
Industrial and Engineering Services

WHB:bw
encls


removable cap
screw (4)
corner support
angle frame
cross bar
(at 4 corners)
hinge
flap
(steel plate)
flap open
non-combustible
cable
pull to open
pull to close

POOR

QUALITY

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